July 23, 2018

Ms. Michelle Kaysen
United States Environmental Protection Agency Region 5
Mail Code LU-9J
77 West Jackson Boulevard
Chicago, Illinois 60604

RE: Response to Additional United States Environmental Protection Agency Comments regarding the *Resource Conservation and Recovery Act (RCRA) Corrective Action Framework, Hartford Petroleum Release Site, Hartford, Illinois*

Dear Ms. Kaysen,

212 Environmental Consulting, LLC on behalf of Apex Oil Company, Inc. (Apex) submitted the *Draft Proposed Multiphase Remedy Framework Remedial Objectives, Remediation Goals, and Performance Metrics, Hartford Petroleum Release Site, Hartford, Illinois* to the United States Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (Illinois EPA) on December 2, 2016. The Illinois EPA provided comments related to the groundwater aspects of the proposed remediation goals, performance metrics, and end points via correspondence dated February 27, 2017. The USEPA, Illinois EPA, Tetra Tech (USEPA contractor), Apex, and 212 Environmental Consulting, LLC (212 Environmental, Apex contractor) met on Tuesday April 25, 2017 to discuss the Illinois EPA comments.

The USEPA subsequently provided comments regarding the proposed remediation goals, performance metrics, and end points via email on July 21, 2017. These comments were compiled from the USEPA RCRA Correction Action Section, Tetra Tech, USEPA Office of Research and Development (ORD), as well as Battelle (the consultant for the USEPA ORD). The Agencies (USEPA and Illinois EPA), Apex, and their respective contractors met on Tuesday September 12, 2017 to discuss the combined USEPA comments.

A response to the Illinois EPA comments dated February 27, 2017 and USEPA comments dated July 21, 2017 were submitted by Apex to the Agencies on December 1, 2017. On January 2, 2018, the USEPA submitted three additional comments related to Apex's responses to the USEPA and Illinois EPA comments.

Apex's response to the three additional comments provided by the USEPA; in addition, to the *Resource Conservation and Recovery Act (RCRA) Corrective Action Framework, Hartford Petroleum Release Site, Hartford, Illinois* (*RCRA Corrective Action Framework*) describing the revised remedial objectives, remediation goals, performance metrics, and end-points were submitted to the USEPA on June 1, 2018.

The USEPA provide an additional comment regarding the third performance metric that was proposed as part of a multiple lines of evidence approach to measure the progress towards achieving Remedial Objective No. 1 (Reduce Mass of Hydraulically Recoverable LNAPL) on June 20, 2018. A response to the USEPA's additional comment is provided herein. The revised *RCRA Corrective Action Framework* is also included as a separate correspondence.

USEPA COMMENTS

USEPA Comment Regarding the Third Performance Metric under Remedial Objective No. 1 (Reduce Mass of Hydraulically Recoverable LNAPL): Apex is proposing to use the "stability action levels" presented in Section 5.5 of the MassDEP guidance. The levels referenced aren't intended to be used for remedial performance metrics. They're intended to be used to determine whether LNAPL is non-stable. The guidance concedes that apparent thickness is "not a perfect instrument" but it's a readily available surrogate to judge whether the plume is sufficient to overcome pore entry pressures and migrate. The action levels are then offered as a means to assess the plume's stability with subsequent monitoring efforts to confirm stability.

Section 5.6 provides the framework for determining the feasibility of removing LNAPL, which is more applicable to our performance metric. This section utilizes the information gained by applying Section 5.5 to determine the need to remove or control non-stable NAPL or NAPL with micro-scale mobility. My original suggestion of this guidance was based on this section because it incorporates the 1/8" regulatory challenge in a way that incorporates other site conditions as well as multiple lines of evidence. The guidance appears to use 1/8" as a benchmark to address certain regulatory paradigms while building a more defensible method around that benchmark. And the method they are presenting seems very much in line with the framework.

> ***Apex Response to Additional USEPA Comment**: The third performance metric for Remedial Objective No. 1 (Reduce Mass of Hydraulically Recoverable LNAPL) was originally discussed in our meeting in September 2017 and further described in the Apex Response to USEPA Comment No. 10 within the correspondence dated December 1, 2017. This third performance metric was subsequently incorporated into the RCRA Corrective Action Framework submitted to the Agencies on June 1, 2018.*
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> *While Performance Metric No. 3 (proposing the adoption of Table 2 from the Massachusetts Department of Environmental Protection (MADEP) Policy No. WSC-16-450 entitled Light Non-Aqueous Phase Liquids and the MCP: Guidance for Site Assessment and Closure) was originally intended to be used for demonstrating LNAPL stability; the LNAPL thickness endpoints described in Table 2 of the MADEP Policy No. WSC-16-450 aligned with the current understanding about LNAPL mobility and recoverability at the Hartford Site based on the extensive pilot testing performed in Area A between 2011 and 2015.*

Apex does not agree with the incorporation of Section 5.6 pf the MADEP Policy No. WSC-16-450 by reference as a replacement to Performance Metric No. 3, as this does not provide a numeric end-point and could be misapplied or misunderstood in the future. This is also not consistent with the approach described within the Interstate Technical and Regulatory Council (ITRC) guidance titled Evaluating LNAPL Remedial Technologies for Achieving Project Goals. Apex understands the goal of the proposed third performance metric is simply to memorialize the alternative of using LNAPL transmissivity in lieu of LNAPL thickness as described on Page 33 of the MADEP Policy No. WSC-16-450, which states:

> *"In lieu of using the generic criteria contained in Figure 8, users of the Simplified approach may choose to conduct a site-specific LNAPL Transmissivity test to demonstrate the infeasibility of commencing LNAPL removal operations. In such cases, the initiation of removal operations may be considered infeasible if the LNAPL Transmissivity value (Tn) in suitable recovery locations are less than 0.8 ft2/day."*

Since LNAPL transmissivity has already been identified as a performance metric to be used within a lines of evidence approach for demonstrating when Remedial Objective No. 1 has been achieved within a Remediation Management Area, it seems unnecessary to also utilize Section 5.6 of the MADEP Policy No. WSC-16-450 as an additional performance metric.

Instead, Apex has revised the RCRA Corrective Action Framework dated June 1, 2018, which is provided with this response as a separate correspondence. The third performance metric for Remedial Objective No. 1 has been removed from the RCRA Corrective Action Framework and a discussion regarding the MADEP adoption of transmissivity as an endpoint used to determine when hydraulically recovery methods have achieved the maximum extent practicable goal has been added under the first performance metric for Remedial Objective No. 1.

If you have any questions, please contact me at (513) 430-1766.

Sincerely,
212 Environmental Consulting, LLC

Paul Michalski, P.G.
Senior Hydrogeologist

cc: Jordy Federko, Apex Oil Company, Inc.
Tom Miller, Illinois Environmental Protection Agency

July 23, 2018

Ms. Michelle Kaysen
United States Environmental Protection Agency Region 5
Mail Code LU-9J
77 West Jackson Boulevard
Chicago, Illinois 60604

RE: Resource Conservation and Recovery Act (RCRA) Corrective Action Framework, Hartford Petroleum Release Site, Hartford, Illinois

Dear Ms. Kaysen,

Apex Oil Company, Inc. (Apex) met with the United States Environmental Protection Agency (USEPA) and Illinois Environmental Protection Agency (Illinois EPA) on October 9, 2014 to have an initial discussion regarding the RCRA Corrective Action Framework for the Hartford Petroleum Release Site (Hartford Site). During this meeting, remedial objectives were agreed upon for future corrective actions at the Hartford Site. The remedial objectives agreed to at the meeting include the following:

- Reduce the mass of hydraulically recoverable (i.e., mobile) light non-aqueous phase liquids (LNAPL)
- Alter the composition of mobile and residual LNAPL
- Protect Village of Hartford residents from risks associated with a completed vapor intrusion pathway
- Restore groundwater to potential beneficial reuses
- Protect against dissolved phase constituent migration to the Village of Hartford drinking water well field

In December 2016, Apex submitted to the USEPA and Illinois EPA proposed remediation goals, performance metrics, and end-points[1] (collectively referred to as the RCRA Corrective Action Framework herein) that could be used to measure progress toward achieving the remedial objectives agreed upon in October 2014, in furtherance of Apex's obligations at the Hartford Site. The Illinois

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[1] As defined within the Interstate Technology and Regulatory Council (ITRC) guidance titled *Evaluating LNAPL Remedial Technologies for Achieving Project Goals* (2009), a remediation goal describes the overarching rationale for conducting corrective action, whereas a performance metric represents a measurable characteristic used to demonstrate progress toward achieving a remediation goal. Ideally, each performance metric has a predetermined value that describes when a corrective action has reached the limits of beneficial application, which is defined as the end-point for the remediation goal.

EPA provided comments related to the groundwater aspects of the proposed RCRA Corrective Action Framework via correspondence dated February 27, 2017. The USEPA, Illinois EPA, Tetra Tech (USEPA contractor), Apex, and 212 Environmental Consulting, LLC (212 Environmental, Apex contractor) met on Tuesday April 25, 2017 to discuss the Illinois EPA comments.

The USEPA subsequently provided comments regarding the RCRA Corrective Action Framework via email on July 21, 2017. These comments were compiled from the USEPA RCRA Corrective Action Section, Tetra Tech, USEPA Office of Research and Development (ORD), as well as Battelle (the consultant for the USEPA ORD). The Agencies (USEPA and Illinois EPA), Apex, and their respective contractors met on Tuesday September 12, 2017 to discuss the combined USEPA comments.

A response to the Illinois EPA comments dated February 27, 2017 and USEPA comments dated July 21, 2017 were submitted by Apex to the Agencies on December 1, 2017. On January 2, 2018, the USEPA submitted three additional comments related to Apex's responses to the USEPA and Illinois EPA comments.

The purpose of this correspondence is to provide the final RCRA Corrective Action Framework for the Hartford Site based on feedback from and discussions with the USEPA and Illinois EPA. Amongst many of the revisions reflected herein, an additional remedial objective was added as follows:

- Protect Village of Hartford residents and construction workers from direct exposure to contaminated shallow surface and subsurface soils

The development of the RCRA Corrective Action Framework follows the process described within the ITRC Guidance entitled *Evaluating LNAPL Remedial Technologies for Achieving Project Goals* (2009), as well as the summary of the remedial strategy and path forward submitted by the USEPA via correspondence on April 14, 2014. The objectives, goals, and metrics described herein are not limited to a single predefined technology; rather, upon agreement of the RCRA Corrective Action Framework, a remedial alternatives analysis will be performed in accordance with the ITRC Guidance (2009) to identify potentially viable remedial technologies, as subsequently confirmed viable through future bench scale and/or pilot testing at the Hartford Site.

In addition, it is anticipated that various technologies may be employed within discrete portions of the Harford Site to achieve the remediation goals and performance metrics described herein. Remediation management areas with similar lithologic settings, LNAPL morphologies, constituents of concern, migration pathways, and receptors were recently agreed upon by Apex, USEPA, and Illinois EPA. These remediation management areas are described within the *Conceptual Site Model, Hartford Petroleum Release Site, Hartford, Illinois* (*Conceptual Site Model*, 212 Environmental 2018). Dividing the site into remediation management areas will allow for more targeted and effective remedial technology selection and implementation, as a single remedial technology is not likely to be solely effective in remediating the entirety of the Hartford Site (or even any given management area) given the heterogeneity in the hydrogeologic setting and LNAPL source zones.

Some remediation goals may be met over a longer timeframe, after the selected active remedial technologies have achieved reasonable endpoints (e.g., asymptotic recovery, net environmental benefit, etc.). It is anticipated that active remedial technologies will focus on mass recovery and altering the composition of mobile and residual LNAPL. It may be necessary in some remediation management areas to employ sequential or parallel active remedial technologies (e.g., air sparging and soil vapor extraction). These active components of the corrective action will be performed over the near term once the RCRA Corrective Action Framework has been approved and remedial alternatives analyses performed. Once all of the selected active remedial technologies for a given remediation management area have reached predefined end-points or asymptotic conditions persist (i.e., diminished ability to reduce mass or concentrations within the LNAPL source zone), site conditions will be determined suitable for a transition to a monitored natural source zone depletion (NSZD) approach or a corrective action completion determination will be requested for the remediation management area. It is anticipated that NSZD processes will drive petroleum hydrocarbon degradation and mass removal until many of the remediation goals and performance metrics are achieved (e.g., restoration of groundwater to practicable reuse). The transition from active remedial technologies in the near term to monitored NSZD over the long term will likely be preceded by cyclical or pulsed operation of specific remedial technologies, in an effort to optimize and maximize the benefits of the active technologies over time. The transition from active remediation to NSZD may proceed at a different timeframe for each remediation management area.

The remainder of this correspondence is divided into the following two sections:

1. Site Setting – provides a brief summary of the geologic, hydrogeologic, and hydraulic setting beneath the Hartford Site. A comprehensive description of the site setting was recently provided within the *Conceptual Site Model* (212 Environmental 2018), and
2. RCRA Corrective Action Framework - describes the remediation goals and performance metrics associated with each of the remedial objectives for the Hartford Site.

SITE SETTING

The Hartford Site is located along the historical edges of the Mississippi and Missouri River flood plains within a shallow valley approximately 30 miles long and 11 miles across at its widest point and underlain by more than 100 feet of unconsolidated deposits created by alluvial and glacial processes during the Pleistocene period. Over the last 125,000 years, the Mississippi River has changed its course frequently resulting in deposition of sediments with widely-varying grain size across a broad area, creating a highly heterogeneous unconsolidated stratigraphy. As a result, the lithology beneath the Hartford Site consists of alternating alluvial deposits of clay and silt overlying a regionally extensive sand deposit referred to as the Main Sand stratum. The Main Sand stratum consists of alluvial sands and coarse grained glacial outwash that ranges from 80 to 100 feet in thickness. The permeable zones within the alluvial deposits overlying the Main Sand are locally known (in descending order) as the North Olive, the Rand, and the EPA hydrostratigraphic units. These permeable zones are bounded by discontinuous clay deposits identified as (in descending order) the A-, B-, C-, and D-Clay. The Main Silt stratum has been described to be present beneath portions of the Hartford Site where these clay lenses are absent.

The A-Clay is continuously present beneath the Hartford Site, with the exception of areas where it has been removed as part of construction activities. The B- and C-Clay are highly discontinuous and of limited aerial extent. The B- and C-Clay define the extent of the North Olive and Rand hydrostratigraphic units, respectively. The North Olive and Rand strata laterally grade into the Main Silt stratum, where the B- and C-Clay are absent. Groundwater within the North Olive, Rand, and Main Silt strata occur as isolated areas of perched water on the surface of the underlying clay. Groundwater is spatially and temporally variable within the shallow strata with recharge occurring via: (1) precipitation and downward migration through the discontinuous and leaky clay lenses and (2) upward vertical migration of groundwater from the deeper hydrostratigraphic units through the discontinuous and leaky clay lenses.

The D-Clay underlies and defines the EPA stratum, which is limited to the northern portions of the Hartford Site. The D-Clay could be considered a discontinuous lens within the Main Sand stratum based on its relative thickness (thickness between approximately 2 to 7 feet) and limited extent. The EPA stratum grades laterally into the Main Sand to the south of a southeasterly trending line extending from the intersection of Old St. Louis Road and North Delmar Avenue to just north of the intersection of East Date Street and North Olive Street. Along this boundary, the EPA and Main Sand strata are hydraulically connected with flow in the EPA stratum towards the southwest.

The Mississippi River is located less than a half mile west of the Hartford Site and is hydraulically connected to groundwater within the Rand, Main Silt, and EPA stratum, as well as the Main Sand. Water level fluctuations in each hydrostratigraphic unit are affected by changes in the Mississippi River stage. Since the river stage varies by more than 20 feet during a year, the groundwater conditions can fluctuate from unconfined to confined conditions. It should be noted that the United States Army Corps of Engineers controls the Mississippi River stage as part of flood prevention efforts up- and down-stream of the Village of Hartford. As such, river stage can fluctuate due to ambient, or natural, conditions (e.g., spring thaw of snow pack, localized precipitation events, drought conditions) but can also be artificially manipulated irrespective of ambient conditions.

Groundwater in the Main Sand stratum within the Village of Hartford is generally unconfined during periods of drought and low Mississippi River stage, which generally occurs for no more than several months each year, typically in the winter (January through March). Groundwater becomes confined by the overlying C- and D-Clay (where present), and in some places by clay lenses within the Main

Silt stratum, during times of normal and high river stage. There are some areas within the Main Sand stratum where confined conditions may persist throughout the entire year, such as the northeast portion of the Hartford Site near the intersection of North Olive Avenue and East Rand Avenue where the D-Clay is present.

Groundwater elevations within the Main Sand hydrostratigraphic unit have fluctuated significantly over the past 50 years. Historical fluid level monitoring data indicate that groundwater elevations reached a high of approximately 415 feet above mean sea level (ft-amsl) during the early-1990s and have been as low as approximately 380 ft-amsl in the mid-1950s, which is typically 10 to 15 feet lower than conditions that have prevailed since 2004. The low groundwater elevations observed during the mid-1950s (that have not been observed since then) may be attributed to (1) the lowest mean Mississippi River stage as a result of extreme drought conditions, and (2) a period of maximum pumping of groundwater from the facilities adjacent to the Hartford Site (USEPA et al. 2010). The United States Army Corp of Engineers constructed Dam No. 27 (a.k.a. the Chain of Rocks Dam), between 1959 and 1963, down-stream of the Hartford Site. This low water dam raised the minimum river stage to 9 feet within the Mississippi River from Dam No. 27 up-stream to the Melvin Price Dam (which replaced Dam No. 26), which also may explain why groundwater elevations in the Main Sand have not reached the historical lows observed in the 1950s.

The natural groundwater flow regime in the Main Sand stratum has been altered beneath the Hartford Site due to pumping on the British Petroleum (approximately 1,225 gallons per minute (gpm)), Phillips66 (more than 6,000 gpm along the river dock and 3,000 gpm on the refinery), and Premcor (approximately 300 gpm) facilities. During periods of high river stage, which are defined by periods when the river stage exceeds 410 ft-amsl (greater than the 75th percentile of all river stage measurements collected since 2004), groundwater flow is generally towards the east to northeast due to recharge from the river and bank storage within the Main Sand stratum. During moderate river elevations, the groundwater flow direction is northward. During low river stages, which are defined by periods when the river elevation is less than 400 ft-amsl (less than the 25th percentile of all river stage measurements collected since 2004), groundwater flow trends northwesterly to westerly. Groundwater flow in the Main Sand stratum beneath the Hartford Site has been in a northerly direction attributed to large scale pumping by these facilities since at least 1951 (Mathes 1979).

In the absence of groundwater production by the various facilities around the Hartford Site, groundwater flow within the Main Sand stratum under typical river stage conditions is likely to flow west towards the Mississippi River. Additionally, it is anticipated that groundwater elevations would increase within the Main Sand stratum beneath the Hartford Site submerging additional portions of the smear zone, resulting in decreased LNAPL transmissivity as groundwater displaces LNAPL within available pore spaces.

As shown on Figure 1, groundwater within the deep portions of the Main Sand stratum are utilized as a drinking water resource by the Village of Hartford, more than 1,700 feet (well beyond the 1,000-foot maximum setback zone) to the southwest of the currently known extent of petroleum hydrocarbons attributed to releases from the refineries and terminals. The two operational groundwater production wells (WSW-3 and WSW-4) operated by the Village of Hartford have a total depth of approximately 105 feet below ground surface (ft-bgs) and were constructed with between 20 and 35 feet of screen. Discontinuous pumping from these wells (average of 150 gpm) is at a much lower rate than that performed on the various facilities located to the north of the well field and does not affect flow direction within the Main Sand aquifer beneath the Hartford Site.

The Village of Hartford well head protection area is situated well beyond the lateral distance expected for dissolved phase petroleum hydrocarbon migration from a LNAPL source zone. There have been numerous studies to evaluate the extent of dissolved phase petroleum hydrocarbon plumes downgradient of LNAPL source zones (Newell et al. 1990, Rice et al. 1995, Groundwater Services, Inc. 1997, Mace et al. 1997, Ruiz-Aguilar 2003). A compilation of plume lengths for dissolved phase benzene from more than 600 petroleum release sites located in California, Texas, and Florida reported an average plume length of 132 feet from the LNAPL source zone with the 90th percentile plume length for benzene approximately 320 feet (Newell and Conner 1998). The majority of the sites included in this study did not have active hydraulic controls limiting potential dissolved phase benzene plume lengths. An additional peer-reviewed study by Shih et al. (2004) of benzene plume lengths at more than 500 petroleum release sites in Los Angeles, California identified an average plume length of 200 feet from the LNAPL source zone with the 90th percentile benzene plume length of 350 feet. Dissolved phase petroleum hydrocarbon plumes are typically limited both laterally and vertically by sorption, dispersion, as well as by aerobic and anaerobic intrinsic biodegradation processes.

The Village of Hartford well head protection area (or the 1,000-foot maximum setback zone) is located more than 700 feet to the southwest of the interpreted extent of petroleum hydrocarbons attributed to historical releases from the Hartford Site. Sustained hydraulic gradients are not present within the Main Sand stratum within the well head protection area due to the cyclical nature of pumping performed within the groundwater production wells. Furthermore, the Village of Hartford production wells are screened more than 40-feet deeper than the extent of dissolved phase hydrocarbons within the Main Sand stratum.

RCRA CORRECTIVE ACTION FRAMEWORK

The remainder of this correspondence describes the remediation goals, performance metrics, end-points, and measurement methods for each of the remedial objectives developed during the October 9, 2014 meeting, as well as the additional remedial objective developed based on feedback from and subsequent discussions with the USEPA and Illinois EPA. A summary of the RCRA Corrective Action

Framework for the Hartford Site is provided on Table 1. Once the RCRA Corrective Action Framework is approved by the USEPA and Illinois EPA, potentially viable remedial technologies will be identified for specific remediation management areas via a remedial alternatives analysis. Appendix I of the *Conceptual Site Model* (212 Environmental 2018) provides an example Table of Contents for future remedial alternatives analyses. Subsequent to submittal of the alternatives analysis for a remediation management area, bench scale and pilot testing will be performed, as necessary, to confirm the effectiveness of selected remedial technologies in achieving remediation goals and performance metrics within a specific remediation management area. Next, implementation plans will be prepared for each remediation management area detailing the use of specific remedial technologies. These implementation plans will also provide the specifics including monitoring locations, constituents of concern, measurement methods, and frequency of monitoring that will be used to demonstrate progress towards each of the applicable remediation goals and performance metrics. Furthermore, specific end-points for selected technologies employed within each remediation management area will be established.

Following implementation, the progress towards achieving the remedial technology end-points, as well as the applicable remediation goals and performance metrics will be periodically reviewed with the USEPA and Illinois EPA (e.g., five-year reviews). Certain performance metrics may need to be reconsidered if asymptotic or other limiting conditions prevail following implementation of the selected technologies. In such cases, reevaluation and selection of alternate performance metrics will be proposed for approval of the USEPA and Illinois EPA.

REMEDIAL OBJECTIVE No. 1: REDUCE MASS OF HYDRAULICALLY RECOVERABLE LNAPL

Remediation Goal[2]: The mass of hydraulically recoverable (i.e., mobile) LNAPL beneath the Hartford Site will be reduced using various remedial technologies selected as part of remedial alternatives analysis within each remediation management area.

> **Performance Metric No. 1**: The mass of LNAPL within the source zone will be reduced such that LNAPL transmissivity (T_n) is below 0.1 to 0.8 square feet per day (ft^2/d). Based on the ITRC

[2] Two performance metrics are proposed for this remedial objective and therefore a multiple lines of evidence approach for evaluating progress towards achieving the remediation goal will be utilized. In some cases, demonstrating that only one of the performance metrics has been reached will show that this remediation goal has been achieved within a remediation management area. However, in other cases, it may be necessary to consider both of the performance metrics when evaluating progress towards achieving this remedial objective. If it is determined that hydraulic recovery of LNAPL is economically feasible and beneficial within a specific remediation area, but one of the proposed end-points for one of the Performance metrics has been achieved (e.g., LNAPL saturation is measured below 10%), Apex would rely on additional lines of evidence to determine when the remedial objective has been achieved (e.g., LNAPL transmissivity), in concurrence with the Agencies.

Guidance (2009), this is the range at which hydraulic recovery can practically reduce T_n, and further lowering of T_n can be inefficient and "without much benefit in terms of reduction of LNAPL mass, migration potential, risk, or longevity."

Measurement Methodology: T_n will be measured in accordance with one or more of the following methods in accordance with the American Society for Testing and Materials (ASTM) *Standard Guide for Estimation of LNAPL Transmissivity* (E2856–11 2012):

- Baildown/Slug Testing – consists of either removing all accumulated LNAPL from the well casing and filter pack (baildown) or the displacement of a partial volume of LNAPL to induce a head differential (slug test). Following the induction of a head differential, fluid levels are gauged during recovery. Baildown or slug testing may be conducted at wells exhibiting sufficient LNAPL thickness (i.e., greater than 0.5 foot).
- Manual LNAPL Skimming Tests - conducted by removing LNAPL at a rate that maintains drawdown in the well until a consistent LNAPL recovery rate is achieved. Manual skimming tests may be completed at wells exhibiting any measurable LNAPL thickness (i.e., greater than 0.01 foot).
- Recovery Data-Based Methods – derives T_n using data obtained from continuous operation of LNAPL skimmer pumps and/or other types of product recovery systems where hydraulic conditions approach steady-state conditions.
- Tracer Test-Based Methods – involves injection of a LNAPL-soluble fluorescent dye or tracer compound into the LNAPL present in a well and monitoring the subsequent decay to derive estimates of LNAPL flux and LNAPL transmissivity. Tracer testing can generally be performed in wells exhibiting LNAPL thicknesses greater than 0.2 foot.

For any of the above T_n measurement methods, fluctuations in the hydraulic conditions that significantly change the groundwater/LNAPL interface elevation during the test can result in inaccurate transmissivity determinations. Per the ASTM Guide, if the water table varies by a magnitude greater than 20% of the maximum drawdown induced over the period of analysis, then an alternative method should be used to evaluate LNAPL transmissivity (ASTM 2012). LNAPL transmissivity data will be analyzed in accordance with the applicable portion of the ASTM Guide using the American Petroleum Institute (API) *LNAPL Transmissivity Workbook: A Tool for Baildown Test Analysis* (API 2012). LNAPL transmissivity[3] may be evaluated on a

[3] LNAPL transmissivity has been accepted by 31 of the 50 states in official correspondence (e.g., technical memo, guidance, regulation, etc.) as "a remedy start-up metric, progress metric, or remedy shutdown metric" (Kimball et al. 2018). Within five of these states, LNAPL transmissivity is accepted as a determination that LNAPL has been recovered to the maximum extent practical (Kimball et al. 2018). For instance, the Massachusetts Department of Environmental Protection (MADEP) has determined that hydraulic LNAPL recovery may be considered infeasible if the LNAPL transmissivity (as determined at suitable recovery locations) is less than 0.8 square feet per day (MADEP 2016).

periodic basis (e.g., as part of 5-year reviews) or as it is determined necessary to evaluate if the performance metric has been achieved within a specific remediation management area.

Performance Metric No. 2: The mass of LNAPL within the source zone will be reduced such that LNAPL saturations are below 10% (MADEP 2016, LPSA 2008). LNAPL saturation is defined as the LNAPL-filled fraction of the total soil pore volume. For example, 10% LNAPL saturation means 10% of the total porosity is filled with LNAPL.

Measurement Methodology: According to ITRC Guidance, LNAPL can never be fully removed from soil by hydraulic recovery, and the lowest LNAPL saturation theoretically attainable by hydraulic recovery is referred to as residual saturation (ITRC 2009). LNAPL present at residual levels (i.e., below the maximum LNAPL saturation) is discontinuous and immobile under the applied gradient (USEPA 1995). While the range of residual saturation depends on the LNAPL type and lithologic setting, as well as saturated versus unsaturated conditions, a LNAPL saturation endpoint of 10% was chosen as this is a typical saturation value below which LNAPL is considered immobile (MADEP 2016, LPSA 2008). Furthermore, LNAPL saturation values within Area A (both historical and recent measurements collected as part of the Area A Additional LNAPL Recovery Pilot Test) ranged from 1.7 – 7.1%, with an average of 4.9% across the smear zone in the Main Sand stratum. Even under extreme groundwater table depression achieved via focused pumping at over 300 gpm, during an already seasonally low water table, LNAPL was not observed to be mobile or potentially recoverable (Trihydro 2015).

Percent LNAPL saturation in subsurface soils will be measured in accordance with one or more of the following methods:

- <u>Measure LNAPL saturations from Undisturbed Soil Cores</u> – Undisturbed soil cores can be collected in the smear zone and analyzed for LNAPL saturations using ASTM Method D-425M or Dean-Stark Extraction methods. Saturations reported via soil coring may be prone to bias as undisturbed soil cores can be difficult to obtain (MADEP 2016).
- <u>Calculate LNAPL saturations based on Total Petroleum Hydrocarbon Analytical Results and Soil Geotechnical Characteristics</u> – The concentration of total petroleum hydrocarbons can be converted to LNAPL saturations with an understanding of the LNAPL and soil physical properties (e.g., porosity, soil bulk density, LNAPL density, etc.) and are relatively straightforward to perform (Hawthorne 2012). LNAPL saturation estimates calculated using the total petroleum hydrocarbon concentrations in soil eliminate uncertainties associated with laboratory analysis of “undisturbed” soil cores.
- <u>Measure LNAPL Saturation from In-Situ Cryogenically Frozen Soil Cores</u> – In-situ cryogenically frozen soil cores can be collected and subsequently analyzed for LNAPL saturation using ASTM Method D-425M or Dean-Stark Extraction methods. Collecting

cores in this fashion allows for complete retention of pore fluids including LNAPL, resulting in greater certainty in the resulting LNAPL saturation measurement.

LNAPL saturations may be evaluated on a periodic basis (e.g., as part of 5-year reviews) or as it is determined necessary to evaluate if the performance metric has been achieved within a specific remediation management area. As the hydrogeologic setting and LNAPL releases are known to be highly heterogeneous, statistical methods may be employed when evaluating LNAPL saturations using the above soil sampling and analytical methods.

REMEDIAL OBJECTIVE NO. 2: ALTER COMPOSITION OF MOBILE AND RESIDUAL LNAPL

Remediation Goal No. 1: The chemical composition of mobile and residual LNAPL will be transformed such that partitioning of volatile petroleum related constituents to the vapor phase will be reduced resulting in an overall elimination of the vapor intrusion pathway, in the absence of remedial or mitigation systems.

Performance Metric and Measurement Methodology: Performance metrics and measurement methods used for evaluating the vapor intrusion pathway are described under Remedial Objective No. 3.

Remediation Goal No. 2: The chemical composition of mobile and residual LNAPL will be altered such that partitioning to the dissolved phase will be reduced resulting in restoration of groundwater to practicable beneficial reuse. Evaluation of the groundwater remediation objectives for the shallow perched hydrostratigraphic units (North Olive, Rand, and Main Silt strata) present in each remediation management area will be developed in accordance with the *Tiered Approach to Corrective Action Objectives* (35 Illinois Administrative Code Part 742). This evaluation will consider the pathway for dissolved phase migration, potential routes of exposure including direct ingestion, and determination of risk based concentration limits for each remediation management area. Groundwater within the Main Sand stratum is utilized as a drinking water resource and the dissolved phase petroleum related constituent concentrations will be compared to Class 1 Groundwater Quality Standards for potable water promulgated within 35 Illinois Administrative Code Part 620 (groundwater quality standards for public water supplies).

Performance Metric and Measurement Methodology: Performance metrics and measurement methods used for evaluating groundwater restoration within the shallow perched and deeper hydrostratigraphic units are described under Remedial Objective No. 4.

REMEDIAL OBJECTIVE NO. 3: PROTECT VILLAGE OF HARTFORD RESIDENTS FROM RISKS ASSOCIATED WITH A COMPLETED VAPOR INTRUSION PATHWAY

Remediation Goal[4]: The vapor intrusion pathway will be rendered incomplete for volatile petroleum related constituents attributed to historical releases from the Hartford Site, under ambient conditions (i.e., in the absence of active remedial technologies or mitigation measures).

Performance Metric: The migration pathway for volatile petroleum related constituents from the source to indoor air will be evaluated to consider completeness of the vapor intrusion pathway, as well as potential inhalation risks for potential receptors. Indoor air, outdoor (ambient) air, sub-slab soil vapor, and soil vapor from monitoring probes will be compared to risk based screening values, such as the USEPA Vapor Intrusion Screening Levels (USEPA 2016) assuming a residential exposure, with a lifetime incremental cancer risk of 1E-06 for carcinogenic constituents and a Hazard Quotient of 1.0 for non-carcinogenic risk. The screening levels will be adjusted for soil vapor by applying an appropriate attenuation factor (USEPA 2015). For noncarcinogenic constituents, the risk based screening values will be adjusted to account for instances where two or more contaminants of concern have the same target organ or mode of action (i.e., similarly acting chemicals) using the Illinois Pollution Control Board mixture rule. The Illinois Pollution Control Board finalized the mixture rule by adopting Dockets B and C, which amended the *Tiered Approach to Corrective Action Objectives* (35 Illinois Administrative Code Part 742). To apply this rule, the risk based screening values for each constituent will be divided by the number of constituents of concern that have the same target organ as a conservative measure to ensure that the combined noncarcinogenic risk from those compounds do not exceed a Hazard Index of 1. For example, if there are three constituents of concern with the same target organ, the risk based screening levels for those constituents will be divided by 3.

Measurement Methodology: Indoor air, outdoor (ambient) air, sub-slab soil vapor, and soil vapor from monitoring probe samples will be collected from representative locations. Representative structures will be selected above the extent of LNAPL within each remediation management area, focusing on those structures with a basement that have historically had a completed vapor intrusion pathway. Soil vapor samples may also be collected from existing vapor monitoring probes located closest to the representative structures but outside of the influence of nearby operating soil vapor extraction wells. Monitoring within the representative structures will be conducted over a range of hydraulic (e.g., seasonally low

[4] The RCRA Corrective Action Framework does not include evaluation of acute risks including explosive conditions or acute inhalation hazards associated with the vapor intrusion pathway. Assessment of the vapor intrusion pathway and performing emergency response activities when action levels and comparison values are exceeded within indoor air will continue to be conducted in accordance with the *Final Interim In-Home Effectiveness Monitoring Work Plan* (Trihydro 2014) or any subsequent Agency-approved updates to the *In-Home Effectiveness Monitoring Work Plan*.

water table, river stage triggered event) and seasonal (e.g., cold ambient air temperature, frozen ground) conditions to assess variability in vapor transport processes. These data will be used to evaluate completeness of the vapor intrusion pathway utilizing a multiple lines of evidence approach as recommended by the USEPA (2015) and ITRC (2014). A key component in determining if volatile constituents from the subsurface are potentially affecting human health within overlying structures is an understanding of the migration route from beneath the structure into indoor air (vapor intrusion pathway). Exceedances of constituents in indoor air could be indicative of a complete pathway for vapor intrusion if those volatile constituents are greater than those expected due to alternate sources within the structure or outdoor air. Volatile constituents are ubiquitous in indoor and outdoor air from a variety of other sources including automobiles, gasoline powered tools, water treatment chemicals and byproducts, a variety of different consumer products, insecticides, pesticides, glues, cleaners, degreasers, lubricants, oils, and building materials. Many volatile petroleum and non-petroleum constituents are present in structures where cigarettes or similar tobacco products are utilized. Furthermore, outdoor air at the Hartford Site contains high levels of volatile petroleum related constituents due to nearby industrial activities, including operations of the petroleum refineries and terminals adjacent to the Village of Hartford. Upward migration of vapors via diffusion and advection from potential sources in soil and groundwater near the residential structures would be offset by dilution with ambient air in the structure.

The vapor intrusion pathway cannot be considered complete unless volatile constituents are measured at higher concentrations beneath the building compared to indoor air. This decrease in the concentration of volatile constituents from soil vapor into indoor air is generally termed attenuation. The soil vapor to indoor air attenuation factor provides the best single line of evidence to indicate whether vapor intrusion may be the cause of volatile constituents detected in indoor air. Extensive studies conducted by the USEPA (2012) have defined the range of attenuation observed within buildings where vapor intrusion has been shown to be occurring. The soil vapor to indoor air attenuation factor (including deeper soil vapor and sub-slab soil vapor) has been conservatively estimated at 0.03 (95% upper confidence interval, USEPA 2012) based on evaluations of the vapor intrusion pathway at structures where the pathway has been determined to be complete. The data set used by the USEPA is based on evaluation of concentrations of chlorinated volatile constituents (i.e., tetrachloroethene and trichloroethene) in and underneath residential buildings. There is limited data regarding attenuation from soil vapor to indoor air within structures underlain by petroleum hydrocarbons, as aerobic biodegradation of volatile petroleum constituents in the vadose zone is a significant mechanism for limiting vapor transport into structures (ITRC 2014). Therefore, the USEPA recommended attenuation factor of 0.03 is conservative for assessment of the vapor intrusion pathway at the Hartford Site, as it does not account for attenuation occurring due to aerobic biodegradation of volatile petroleum hydrocarbons in the vadose zone. Multiple lines of evidence will be considered to determine if the vapor intrusion pathway is complete and to determine if there are potential inhalation risks associated with migration of volatile constituents from petroleum hydrocarbon sources located in the subsurface.

REMEDIAL OBJECTIVE NO. 4: RESTORE GROUNDWATER TO PRACTICABAL BENEFICIAL REUSES

Remediation Goal No. 1: Restore groundwater present in the shallow perched hydrostratigraphic units (i.e., North Olive, Rand, and Main Silt strata) to practicable beneficial reuse.

Performance Metric: Groundwater present in the shallow perched hydrostratigraphic units present in each remediation management area will be developed in accordance with the *Tiered Approach to Corrective Action Objectives* (35 Illinois Administrative Code Part 742). This evaluation will consider the pathway for dissolved phase migration, potential routes of exposure including direct ingestion, and determination of risk based concentration limits for each remediation management area. A pathway evaluation will be conducted to evaluate potential receptors and routes of exposure (including dermal, ingestion, and inhalation routes) in development of these risk based screening objectives for the shallow perched hydrostratigraphic units.

Measurement Methodology: Samples will be collected from monitoring locations screened in the perched hydrostratigraphic units for laboratory analysis of select dissolved phase constituents of concern (includes benzene, toluene, ethylbenzene, xylenes, arsenic, and lead) when the groundwater is gauged to be within the screened interval of the monitoring well or multipurpose monitoring point, determined via manual gauging. Groundwater samples will not be collected if LNAPL is measured within a well or if a LNAPL sheen was observed on the groundwater during purging activities. The analytical results for groundwater samples collected when the screen is occluded generally exhibit a low bias (or diluted results for dissolved phase constituents). The analytical results for groundwater samples collected when LNAPL is present generally exhibit a high bias due to the presence entrained non-dissolved petroleum hydrocarbons (Zemo 2006).

Remediation Goal No. 2: Groundwater within the Main Sand stratum (aka, American Bottoms Aquifer) and the hydraulically connected EPA stratum to practicable beneficial reuse.

Performance Metric: Groundwater within the deep portions of the Main Sand stratum are utilized as a drinking water resource, as such, dissolved phase petroleum related constituent concentrations will be compared to the Class 1 Groundwater Quality Standards for potable water promulgated within 35 Illinois Administrative Code Part 620 (groundwater quality standards for public water supplies).

Measurement Methodology: Groundwater samples will be routinely collected from a network of monitoring locations screened within the upper portions of the Main Sand and EPA strata (where the EPA stratum is present) within the horizontal and vertical limits of historical releases attributed to the Hartford Site. Samples will be collected for laboratory analysis of select dissolved phase constituents of concern (includes benzene, toluene, ethylbenzene, xylenes, arsenic, and lead) when the groundwater is gauged to be within the screened interval of the monitoring well or multipurpose monitoring point, determined via manual gauging. Samples will not be collected if LNAPL is measured within a well or if a LNAPL sheen was observed on the groundwater during purging activities. The analytical results for groundwater samples collected when the screen is occluded generally exhibit a low bias (or diluted results for dissolved phase constituents). The analytical results for groundwater samples collected when LNAPL is present generally exhibit a high bias due to the presence entrained non-dissolved petroleum hydrocarbons (Zemo 2006).

REMEDIAL OBJECTIVE NO. 5: PROTECT THE VILLAGE OF HARTFORD DRINKING WATER WELL FIELD FROM THE MIGRATION OF DISSOLVED PHASE PETROLEUM HYDROCARBONS ATTRIBUTED TO HISTORICAL RELEASES FROM THE FORMER REFINERIES

Remediation Goal: Groundwater within the deep portions of the Main Sand stratum are utilized as a drinking water resource, as such, the dissolved phase petroleum related constituent of concern concentrations (includes benzene, toluene, ethylbenzene, xylenes, arsenic, and lead) will be compared to the Class 1 Groundwater Quality Standards for potable water promulgated within 35 Illinois Administrative Code Part 620 (groundwater quality standards for public water supplies).

Performance Metric No. 1: Dissolved phase petroleum related constituent concentrations will be compared to the Class 1 Groundwater Quality Standards for potable water promulgated within 35 Illinois Administrative Code Part 620 (groundwater quality standards for public water supplies).

Measurement Methodology: Groundwater samples will be routinely collected from the sentinel monitoring network situated between the southern extent of dissolved phase petroleum hydrocarbons in the Main Sand stratum and the Village of Hartford well head protection area. There are five sentinel groundwater monitoring wells (HMW-025 through HMW-029) located between the well head protection area and the interpreted extent of the petroleum hydrocarbons beneath the Hartford Site. These monitoring wells are screened within the upper portions of the Main Sand stratum (between 25 and 39.7 ft-bgs) and provide a conservative means of assessing protection of the Village of Hartford well head protection area from migration of petroleum related constituents attributed to historical releases from the former refineries.

While it is not anticipated that dissolved phase petroleum hydrocarbons will migrate from the Hartford Site to the well head protection area, even under ambient groundwater flow conditions, groundwater samples will continue to be collected and analyzed for select dissolved phase constituents within the sentinel monitoring network until groundwater within the Main Sand stratum beneath the Hartford Site is appropriately restored. The frequency and location of monitoring may be reduced pending the following:

- Contaminant fate and transport modeling
- Final correction action selection
- Development of performance monitoring plans for selected remedial alternatives
- Establishment of baseline conditions for performance monitoring
- Periodic geostatistical evaluation of the performance monitoring network and/or monitoring frequency to identify potential modifications and/or reductions in the network and monitoring requirements while sustaining effective performance monitoring of the selected corrective actions

Performance Metric No. 2: Modeled dissolved phase petroleum related constituent concentrations within the Village of Hartford well head protection area will be compared to the Class 1 Groundwater Quality Standards for potable water promulgated within 35 Illinois Administrative Code Part 620 (groundwater quality standards for public water supplies).

Measurement Methodology: The dissolved phase constituent concentrations within deeper portions of the Main Sand stratum located within the limits of the Village of Hartford well head protection area will be modeled under ambient (non-pumping) and stressed (pumping) conditions using MODFLOW, Bioscreen, or comparable software, if pumping at the British Petroleum, Phillips 66, and Premcor facilities continue to influence groundwater flow directions beneath the Village of Hartford, once it is determined that corrective action is complete within a remediation management area. The model can be calibrated using groundwater analytical results and hydraulic data collected routinely from the sentinel monitoring wells and other monitoring wells and multipurpose monitoring points installed across the Hartford Site. The model selected will account for attenuation of dissolved phase petroleum hydrocarbons along the migration pathway both vertically and laterally away from the source zone. However, if the production wells on the British Petroleum, Phillips 66, and Premcor facilities are not operating or pumping rates are reduced such that ambient flow conditions are present within the Main Sand stratum prior to completion of the selected corrective actions within a remediation management area, groundwater samples will be collected directly from the sentinel monitoring network as described in Performance Metric No. 1.

REMEDIAL OBJECTIVE No. 6: ELIMINATE DIRECT EXPOSURE TO CONTAMINATED SURFACE AND SHALLOW SUBSURFACE SOILS

Remediation Goal No. 1: Protect residents from risks associated with direct exposure to contaminated surface soils, defined as 0 to 3 ft-bgs.

Performance Metric: The laboratory analytical results for shallow surface soil samples (0 to 3 ft-bgs) will be compared to the residential soil USEPA Regional Screening Levels (RSLs). The residential soil RSLs are conservative risk based screening values that consider residential exposure through ingestion, dermal, and inhalation pathways assuming a carcinogenic risk of 1E-6 and a noncarcinogenic Hazard Quotient of 1. The non-carcinogenic RSLs will be adjusted for those constituents with similar modes of action or target organs. Background concentrations of petroleum related constituents of concern will also be considered.

Measurement Methodology: Shallow surface soil samples (0 to 3 ft-bgs) will be collected from limited areas where shallow releases of petroleum hydrocarbons have been previously documented to have occurred (i.e., surface releases), based on historical documentation. A soil sampling program will be developed for each remediation management area and will include sample locations, depth intervals, and a list of potential constituents of concern. Some constituents may be present in surface soil as a result of both natural and man-made conditions (such as naturally occurring arsenic and arsenic from pesticide applications). Therefore, background concentrations will be considered when evaluating soil sample results to determine if measured concentrations are present as a results of background conditions or are present as a result of historical petroleum releases.

Remediation Goal No. 2: Protect construction workers from risks associated with direct exposure to contaminated shallow subsurface soils, defined as 3 to 10 ft-bgs, unless sub-grade utilities are present at deeper depths.

Performance Metric: The laboratory analytical results for shallow subsurface soil samples (3 to 10 ft-bgs) will be compared to risk based clean-up criteria based on a construction worker scenario. The construction worker scenario clean-up criteria will be developed based on applicable USEPA guidance including but not limited to the *Soil Screening Guidance* (USEPA 1996) and the *Supplemental Soil Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002) for a construction worker scenario. Screening levels for the construction worker scenario will assume a 1E-06 lifetime incremental cancer risk (carcinogenic constituents) and

Hazard Quotient of 1 (non-carcinogenic constituents assuming mixture rule). Background concentrations of petroleum related constituents of concern will also be considered.

Measurement Methodology: Shallow subsurface soil samples (3 to 10 ft-bgs) will be collected from limited areas where shallow subsurface soil releases have been previously documented to have occurred (i.e., pipeline releases), based on historical documentation. A soil sampling program will be developed for each remediation management area and will include sample locations, depth intervals, and a list of potential constituents of concern. Deeper sample intervals may be included if sub-grade utilities are present below 10 ft-bgs within a remediation management area. Some constituents may be present in subsurface soil as a result of both natural and man-made conditions (such as naturally occurring arsenic and arsenic from pesticide applications). Therefore, background concentrations will be considered when evaluating soil sample results to determine if measured concentrations are present as a results of background conditions or are present as a result of historical petroleum releases.

PATH FORWARD

Apex is seeking written approvals from the USEPA and Illinois EPA regarding the RCRA Corrective Action Framework described herein and summarized on Table 1. Apex would like to obtain Agency-approval prior to submitting the draft remedial alternative analysis for the first remediation management area. The draft *Remedial Alternative Analysis for Remediation Management Area No. 1* is currently scheduled to be submitted to the USEPA and Illinois EPA on August 13, 2018.

If you have any questions, please contact me at (513) 430-1766.

Sincerely,
212 Environmental Consulting, LLC

Paul Michalski, P.G.
Hydrogeologist

cc: Jordy Federko, Apex Oil Company, Inc.
Tom Miller, Illinois Environmental Protection Agency

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TABLES

TABLE 1. DRAFT MULTIPHASE REMEDY FRAMEWORK OBJECTIVES, GOALS, AND METRICS SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Remedial Objective	Remediation Goal	Timeframe	Performance Metric	End-Point	Measurement Methodology
(1) Reduce mass of hydraulically recoverable LNAPL	Reduce mass of hydraulically recoverable LNAPL beneath the Site using various remedial technologies selected as part of future engineering alternatives analysis	Short-Term	(i) LNAPL Transmissivity (Tn)[1]	0.1 - 0.8 ft^2/d	One or more of the following: - Baildown/Slug Testing - Manual LNAPL Skimming Tests - Recovery Data-Based Methods - Tracer Test-Based Methods
			(ii) Percent LNAPL Saturation[1]	10%	One or more of the following: - Direct Measurement of "Undisturbed" Soil Core - Calculated from TPH concentrations in soil samples - Direct Measurement from Cryogenic Core
(2) Alter composition of mobile and residual LNAPL	(1) Transform chemical composition of LNAPL to reduce partitioning of volatile constituents to eliminate the vapor intrusion pathway under ambient conditions (i.e., no active systems)	Intermediate	Completeness of the vapor intrusion pathway	Incomplete vapor intrusion pathway via evaluation of multiple lines of evidence including comparison of soil vapor and ambient air samples to risk based screening levels. Screening levels for residential exposure will assume a 1E-06 lifetime incremental cancer risk (carcinogenic constituents) and HQ of 1 (non-carcinogenic constituents)	Collect and evaluate indoor air, outdoor air, sub-slab, and soil vapor samples
	(2) Transform chemical composition of LNAPL to reduce partitioning to dissolved phase to restore groundwater to practicable beneficial reuse		(i) Dissolved phase constituent concentrations in perched hydrostratigraphic units (i.e., North Olive, Rand, and Main Silt strata)	Risk based clean-up criteria based on pathway evaluation conducted in accordance with TACO	Collect and analyze groundwater samples from representative monitoring locations screened in the perched hydrostratigraphic units (i.e., North Olive, Rand, and Main Silt strata)
			(ii) Dissolved phase constituent concentrations in deeper hydrostratigraphic units (i.e., EPA and Main Sand strata)	Class 1 Groundwater Quality Standard	Collect and analyze groundwater samples from representative monitoring locations screened in the deeper hydrostratigraphic units (i.e., EPA and Main Sand strata)
(3) Protect Village of Hartford residents from risks associated with completed vapor intrusion pathway	Eliminate the vapor intrusion pathway under ambient conditions (i.e., no active systems)	Intermediate	Completeness of the vapor intrusion pathway	Incomplete vapor intrusion pathway via evaluation of multiple lines of evidence including comparison of soil vapor and ambient air samples to risk based screening levels. Screening levels for residential exposure will assume a 1E-06 lifetime incremental cancer risk (carcinogenic constituents) and HQ of 1 (non-carcinogenic constituents)	Collect and evaluate indoor air, outdoor air, sub-slab, and soil vapor samples
(4) Restore groundwater to practicable beneficial reuses	(1) Restore groundwater in perched hydrostratigraphic units (i.e., North Olive and Rand strata) to practicable beneficial reuses	Long-Term	Dissolved phase constituent concentrations in perched hydrostratigraphic units (i.e., North Olive, Rand, and Main Silt strata)	Risk based clean-up criteria based on pathway evaluation conducted in accordance with TACO	Collect and analyze groundwater samples from representative monitoring locations screened in the perched hydrostratigraphic units (i.e., North Olive, Rand, and Main Silt strata)
	(2) Restore groundwater in deep hydrostratigraphic units (i.e., Main Sand and EPA strata) to practicable beneficial use		Dissolved phase constituent concentrations in deeper hydrostratigraphic units (i.e., EPA and Main Sand strata)	Class 1 Groundwater Quality Standard	Collect and analyze groundwater samples from representative monitoring locations screened in the deeper hydrostratigraphic units (i.e., EPA and Main Sand strata)
(5) Protect the Village of Hartford drinking water well field from the migration of dissolved phase petroleum hydrocarbons attributed to historical releases from the former refineries[2]	Prevent migration of dissolved phase petroleum hydrocarbons to the Village of Hartford drinking water well field[1]	Long-Term	(i) Dissolved phase constituent concentrations in Main Sand stratum	Class 1 Groundwater Quality Standard	Collect and analyze groundwater samples from the sentinel groundwater monitoring network
			(ii) Model the dissolved phase constituent concentrations within the deeper portions of the Main Sand stratum within the Village of Hartford well head protection area	Class 1 Groundwater Quality Standard	Modeling of the dissolved phase constituent concentrations under ambient (non-pumping) and stressed (pumping) conditions using MODFLOW, Bioscreen, or comparable model

TABLE 1. DRAFT MULTIPHASE REMEDY FRAMEWORK OBJECTIVES, GOALS, AND METRICS SUMMARY

HARTFORD PETROLEUM RELEASE SITE, HARTFORD, ILLINOIS

Remedial Objective	Remediation Goal	Timeframe	Performance Metric	End-Point	Measurement Methodology
(6) Eliminate direct exposure to contaminated surface and shallow subsurface soils	(1) Protect residents from risks associated with direct exposure to contaminated surface soils, defined as 0 to 3 ft-bgs	Intermediate	Shallow surface soil concentrations (0 to 3 ft-bgs)	USEPA Regional Screening Levels (RSLs) will be used as conservative soil screening values that consider exposure through ingestion, dermal, and inhalation pathways assuming a carcinogenic risk of 1E-6 and a noncarcinogenic HQ of 1. The non-carcinogenic RSLs will be adjusted for those constituents with similar modes of action or target organs. Background soil concentrations will also be considered.	Collect and analyze soil samples from limited areas where shallow soil releases (0 to 3 ft-bgs) have been previously documented to have occurred (i.e., surface releases)
	(2) Protect construction workers from risks associated with direct exposure to contaminated shallow subsurface soils, defined as 3 to 10 ft-bgs, unless sub-grade utilities are present at deeper depths		Shallow subsurface soil concentrations (3 to 10 ft-bgs)	Risk based clean-up criteria based on pathway evaluation conducted in accordance with applicable USEPA guidance including but not limited to the USEPA Soil Screening Guidance (USEPA 1996) and the Supplemental Soil Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002) for a construction worker scenario. Screening levels for the construction worker scenario will assume a 1E-06 lifetime incremental cancer risk (carcinogenic constituents) and HQ of 1 (non-carcinogenic constituents assuming mixture rule). Background soil concentrations will also be considered.	Collect and analyze soil samples from limited areas where shallow subsurface soil releases (3 to 10 ft-bgs) have been documented to have occurred (i.e., pipeline corridors)

Notes:

1 - Two performance metrics are proposed for this remedial objective and therefore a multiple lines of evidence approach for evaluating progress towards achieving the remediation goal will be utilized. In some cases, demonstrating that only one of the performance metrics has been reached will show that this remediation goal has been achieved within a remediation management area. However, in other cases, it may be necessary to consider both of the performance metrics when evaluating progress towards achieving this remedial objective.

2 - The performance metrics for this remedial objective and remediation goal could be achieved via either: (i) demonstration of the first performance metric under ambient (non-pumping) conditions or near ambient conditions (groundwater flow direction in the Main Sand stratum beneath the Village of Hartford is no longer influenced by pumping from the nearby British Petroleum, Phillips 66, and Premcor facilities) or (ii) via demonstration of the first **and** second performance criteria if pumping continues to influence groundwater flow directions beneath the Village of Hartford, once it is determined that corrective action is complete within a remediation management area.

HQ - Hazard Quotient

LNAPL - Light Non-Aqueous Phase Liquids

TACO - Illinois Environmental Protection Agency Tiered Approach to Corrective Action Objectives (35 Illinois Admin. Code Part 742)

FIGURES

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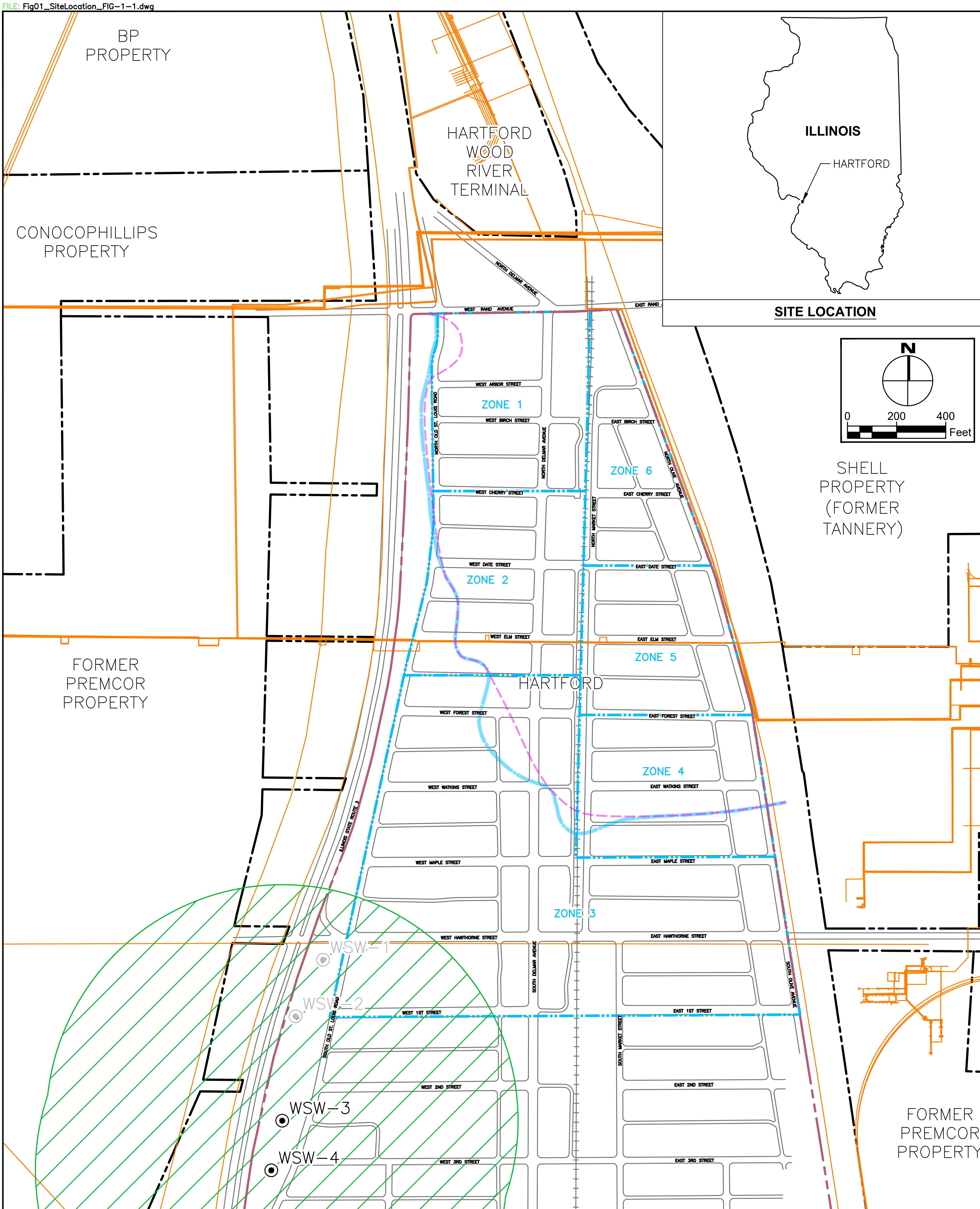

EXPLANATION

WSW-3	VILLAGE PRODUCTION WELL AND DESIGNATION		HARTFORD PETROLEUM RELEASE SITE BOUNDARY (APPROXIMATE)
WSW-1	VILLAGE PRODUCTION WELL AND DESIGNATION (ABANDONED)		INTERPRETED EXTENT OF LIF RESPONSE (ALL STRATA)
	PROPERTY BOUNDARY (APPROXIMATE)		INTERPRETED EXTENT OF DISSOLVED PHASE BENZENE (2018, MAIN SAND)
	VILLAGE OF HARTFORD 1,000-FT MAXIMUM SETBACK ZONE		REFINERY AND TERMINAL PIPELINE
			SOIL VAPOR EXTRACTION EFFECTIVENESS ZONE

NOTE: INTERPRETED EXTENT OF ROST RESPONSE FROM APPENDIX A OF "ACTIVE LNAPL RECOVERY SYSTEM 90% DESIGN REPORT", CLAYTON GROUP SERVICES, INC. (JULY 31, 2006) UPDATED USING 2013 UVOST RESULTS.

TITLE: FIGURE 1. SITE LAYOUT	1" = 400' SCALE.	17-001-06 PROJECT NO.	05/31/18 DATE.
SITE: HARTFORD PETROLEUM RELEASE SITE HARTFORD, ILLINOIS	CDM DRAWN.	TAA CHECKED.	REV. 0 REVISION.

TWO ONE TWO ENVIRONMENTAL

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